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KETCHIKAN, ALASKA BACTERIOLOGICAL SURVEY. TECHNICAL ASSISTANCE AND INVESTIGATIONS

Federal Water Pollution Control Administration
Portland, Oregon

August 1969

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KETCHIKAN, ALA
BACTERIOLOGICAL SKA
URVEY

TECHNICAL ASSIST
AND INVESTIGAT
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IONS

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Springfield VA 22151

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northwest Region
August 1969

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INTRODUCTION

Problem

The sewage disposal system at Ketchikan, Alaska discharges raw sewage directly into the adjacent marine waters of Tongass Narrows. Civil authorities have been concerned over the continuation of this practice because of increasing volume of sewage discharged into the receiving water. The question of whether or not water quality standards were being met in the Tongass Narrows could not be answered because sufficient data were not available. The Ketchikan Gateway Borough, seeking to answer this question, requested federal assistance in conducting a water quality survey of Tongass Narrows.

Objectives and Scope

The purpose of this study is to document the bacteriological water quality of Tongass Narrows with respect to the effects of raw sewage outfalls from the city of Ketchikan, Alaska. The study was limited geographically to the section of Tongass Narrows between Ward Cove and the Ketchikan U.S. Coast Guard Station. The study was conducted May 7 through May 12, 1969. This time period was selected to avoid possible influence from fish processing wastes discharged to the area later in the season.

Authority

The Ketchikan Gateway Borough, by Resolution No. 61 of September 3, 1968, requested assistance from the Alaska Housing Authority in obtaining a water quality survey of Tongass Narrows. The Office of the Governor of Alaska and the Alaska Housing Authority requested that the Federal Water Pollution Control Administration, Alaska Water Laboratory, College Alaska, conduct a water quality survey of Tongass Narrows. Copies of these requesting documents are in the Appendix of this report. The Federal Water Pollution Control Act, as amended provides authority for this study.

Acknowledgments

The assistance and cooperation of the City of Ketchikan, and the Alaska Department of Health and Welfare, Division of Public Health are gratefully acknowledged. Special thanks are offered to the U.S. Bureau of Commercial Fisheries for providing laboratory facilities.

SUMMARY

Findings

1. Total coliform bacterial densities in the waters of Tongass Narrows, adjacent to Ketchikan, Alaska were in violation of State water quality standards. (Standards stated on page 13.)

2. At the shoreline, the total coliform densities associated with the Dock, Mission and Mill Street sewage discharges were as much as a thousand times greater than the State water quality standards; the total coliform densities were still in violation of the standards 400 feet offshore.

3. Total coliform densities near the sewage outfalls were markedly higher at the surface than at depths.

4. Prevailing winds tended to push the surface water towards the east shore of Tongass Narrows, along the City waterfront.

5. Currents within Tongass Narrows have a predominant northward movement and are stronger at mid-channel than near the shoreline.

6. Fecal solids and shredded toilet paper, which are potential health hazards as well as aesthetically offensive, were observed on numerous occasions along the shoreline and floating within Bar Harbor, near Bar Point, and alongside the Dock, Mission and Mill Street area. (See Fig. 2)

7. Total and fecal coliform bacteria from the pulp mill area at Ward Cove did not significantly affect bacterial densities measured in Tongass Narrows within the Ketchikan city limits.

Conclusions

1. The raw sewage outfalls of Ketchikan, Alaska are responsible for the preponderance of coliform bacteria found in the adjacent waters of Tongass Narrows. The sewage disposal practices at Ketchikan result in serious bacterial contamination of the adjacent waters of Tongass Narrows, and an accumulation of fecal solids and associated refuse in the nearshore surface waters and on the shoreline.

2. Pathogenic bacteria and viruses associated with untreated sewage, as indicated by observed high coliform densities, pose a potentially serious public health hazard to water-contact users of the Ketchikan waterfront.

3. Present sewage discharges at Ketchikan are confined near the water surface, and are moved generally northward along the city waterfront by the combined action of winds and tidal currents in Tongass Narrows.

Recommendations

It is recommended that:

1. Sewage at Ketchikan be intercepted; collected and provided at least primary treatment with effluent chlorination (disinfection).

2. The treated sewage be discharged to Tongass Narrows through an adequately designed deep water diffuser-outfall submerged to at least 100 feet of depth.

3. The outfall be located near the northern edge of the city to take advantage of the northward predominance of currents in Tongass Narrows.

STUDY AREA DESCRIPTION

Geography

The city of Ketchikan is located in southeastern Alaska on the west side of Revillagigedo Island along the Tongass Narrows (see Fig. 1). The precipitous rise of the Island restricts building to a narrow strip along the shoreline.

Tongass Narrows, part of the famed Inside Passage, extends approximately 12 nautical miles in a northwest/southeast direction connecting the northerly ends of Revillagigedo Channel and Nichols Passage with Clarence Strait and Behm Canal. For most of its length Tongass Narrows has depths of about 120 feet.

Economy

Wood products and fishing industries provide the base for Ketchikan's economy. The Ketchikan Pulp Company, located north of the city at Ward Cove, produces about 220,000 tons of dissolving grade pulp annually. Ketchikan is also the site of the largest sawmill operation in Alaska; the Ketchikan Spruce Mill employs over 100 men and has a production potential of 210,000 board-feet per 8-hour shift.

Three salmon canneries are located in Ketchikan. The value of Southeast Alaska salmon pack has been increasing in recent years reaching a peak of $53,000,000 in 1966. Halibut processing also is economically important to this area. In 1966 Ketchikan cold storage plants processed 19,000,000 pounds of halibut.

Water Uses

The water quality of Tongass Narrows may affect many commercially valuable fish and shellfish including crabs, scallops, salmon and halibut. The city of Ketchikan receives income not only from the harvesting and processing of these fish, but also from the maintenance and moorage of the fishing fleet.

Recreational use of Tongass Narrows is also important to this area. Tour ships, each containing several hundred tourists, traverse

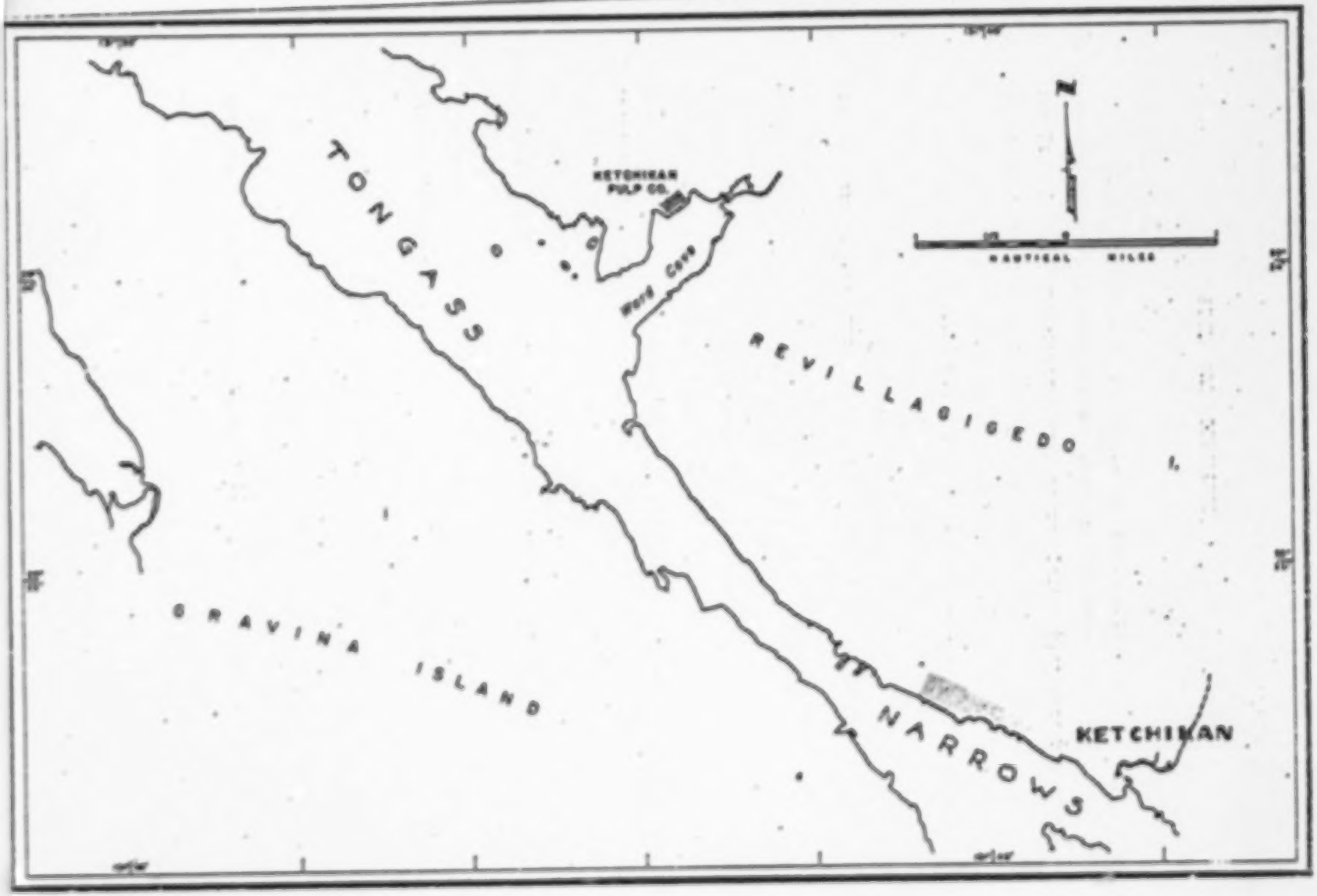
KETCHIKAN PULP CO.
TONGASS
NARROWS
REVILLAGIGEDO I.
GRAVINA ISLAND
KETCHIKAN
N
NAUTICAL MILES

FIGURE 1

the Inside Passage from May through October, making approximately 140 landings at Ketchikan each year. Ketchikan also has three small boat harbors, each of which is heavily used by local residents.

Swimming in Tongass Narrows is not common within the city limits of Ketchikan due to the coldness of the water. Several shallow areas near the city do, however, become warm enough to attract swimmers. Substantial towboating, log-rafting and similar activities are conducted in and around the Ketchikan waterfront.

Bacteriological Waste Sources

Sewage collection systems serve most of Ketchikan's population of more than eight thousand. The collected sewage is discharged untreated to Tongass Narrows through eighteen shallow outfalls located along the shoreline as shown in Fig.2. Several of these outfalls are exposed at low tide. The combined volume of sewage discharged is estimated at 4,000,000 gallons per day.

Individual septic tank or cesspool discharges and watercraft sewage discharges contribute additional domestic sewage. These additional discharges are relatively small in volume and are spread over a large area. Past studies indicate that widely spread small discharges such as these produce only localized effects on water quality.

Many industrial wastes contain coliform bacteria. Pulp mills and fish cannery wastes fall into this category. Survey dates were selected to include a period when the canneries were not operating in order to avoid confusing coliforms derived from industrial sources with those of Ketchikan's municipal sewage. This procedure was not possible with regard to the Ketchikan pulp mill because it operates year round. A series of samples was taken to monitor the possible contribution of this industrial discharge.

SAMPLING AND ANALYTICAL PROGRAM

Bacteriological

Eighteen bacteriological sampling stations were initially established along the Ketchikan waterfront based upon the location

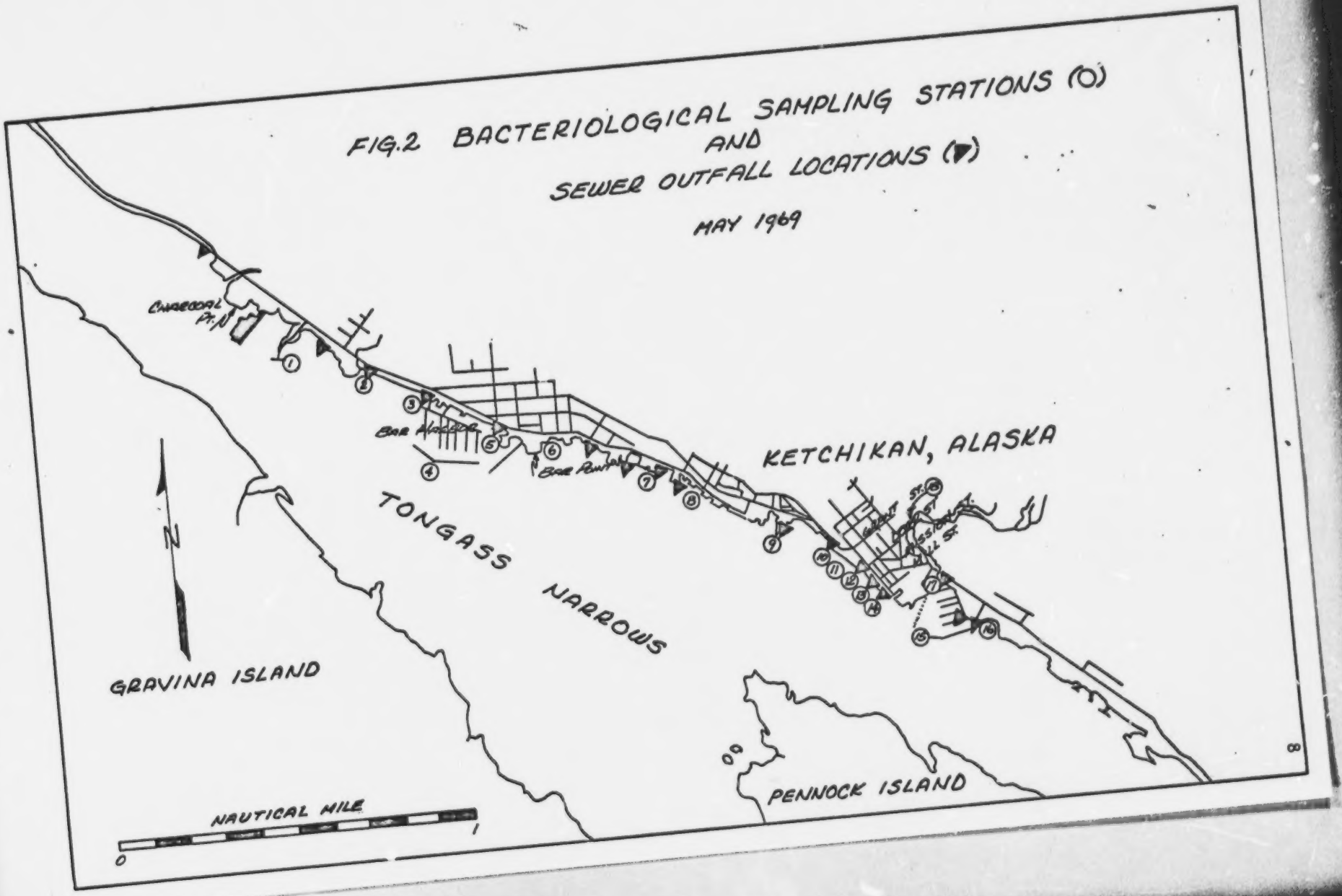
FIG.2 BACTERIOLOGICAL SAMPLING STATIONS (O)
AND
SEWER OUTFALL LOCATIONS (▼)
MAY 1969
CHARCOAL Pt.
KETCHIKAN, ALASKA
TONGASS NARROWS
GRAVINA ISLAND
PENNOCK ISLAND
N
NAUTICAL MILE
0
1

of domestic sewage outfalls (Fig. 2). Most of the samples were collected at the pier head line (see Appendix for description of locations). The time of sampling was initially chosen to coinicide with the worst anticipated conditions for bacterial pollution. Maximum bacterial densities can be expected when peak sewage flow is discharged into a minimum volume of quiescent receiving water. A period when minus low tide slack water corresponded with high human activity was selected as representative of the worst condition.

Additional sample stations were later added, as shown in Fig's 3 and 4, and sample times altered to determine the extent of affected area and the range of bacterial densities. Surface samples were taken during each station visit, and depth samples were collected intermittently. Surface samples were collected by hand in sterile plastic wide mouth bottles. Depth samples were taken with a Kemmerer* sampler and transferred into sterile plastic bottles. Prior to use the Kemmerer sampler was thoroughly flushed with the water to be sampled to prevent contamination of the sample.

Sample documentation included the sample location, sample time, water temperature and remarks (e.g. observed floating fecal solids).

At the laboratory each sample was assigned a correlating laboratory number, and immediately processed for total and fecal coliforms by the membrane filter method. Bacteriological examinations were conducted in accordance with "Standard Methods for the Examination of Water and Waste-Water", (12th Edition, Amer. Publ. Health Assoc.).

* Use of product and company names is for identification only and does not constitute endorsement by the U.S. Department of the Interior or the Federal Water Pollution Control Administration.

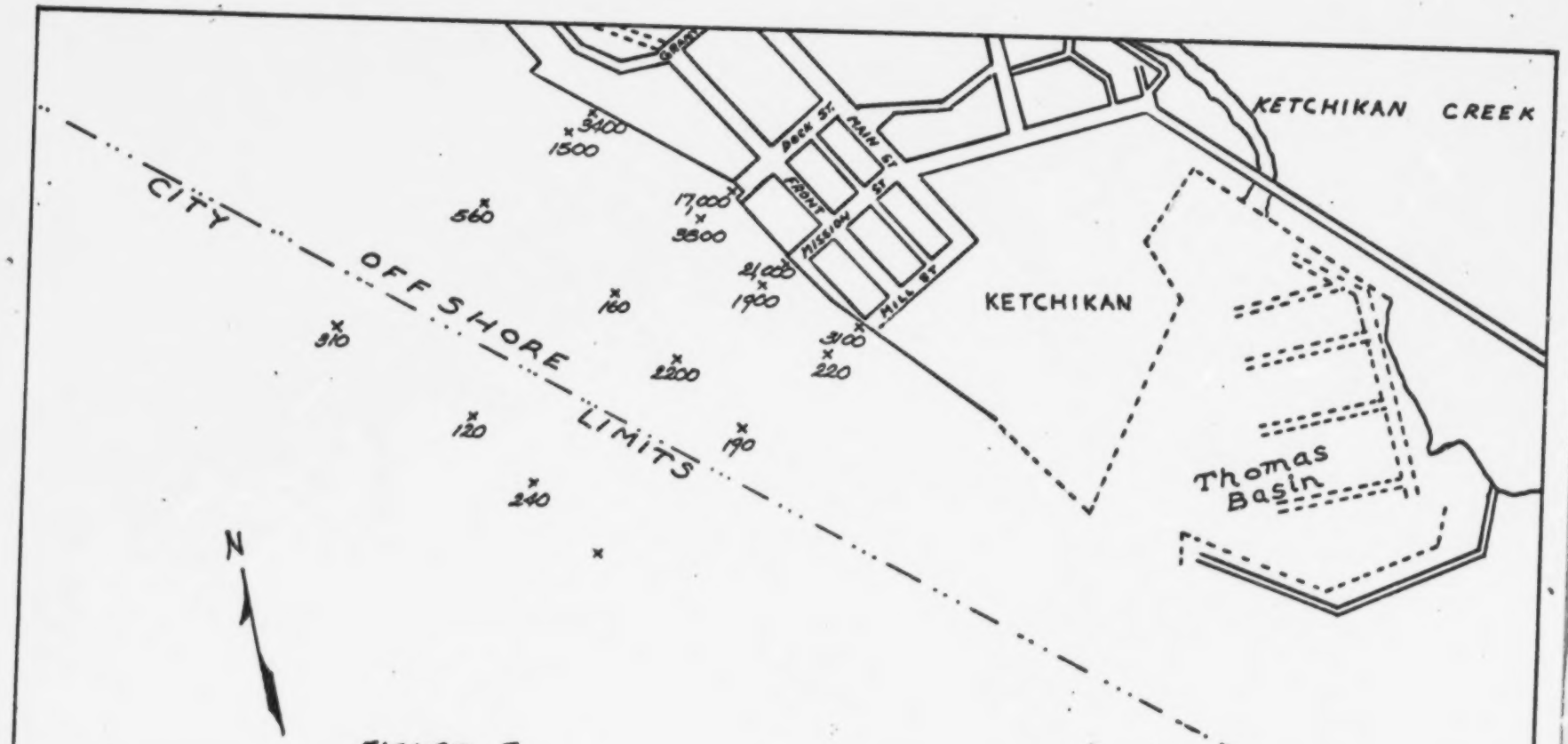

FIGURE 3

GEOMETRIC MEAN OF TOTAL COLIFORM DENSITIES PER 100ml FOR DOWNTOWN KETCHIKAN - OFFSHORE STATIONS

MAY 12, 1969

SCALE 1" = 400'

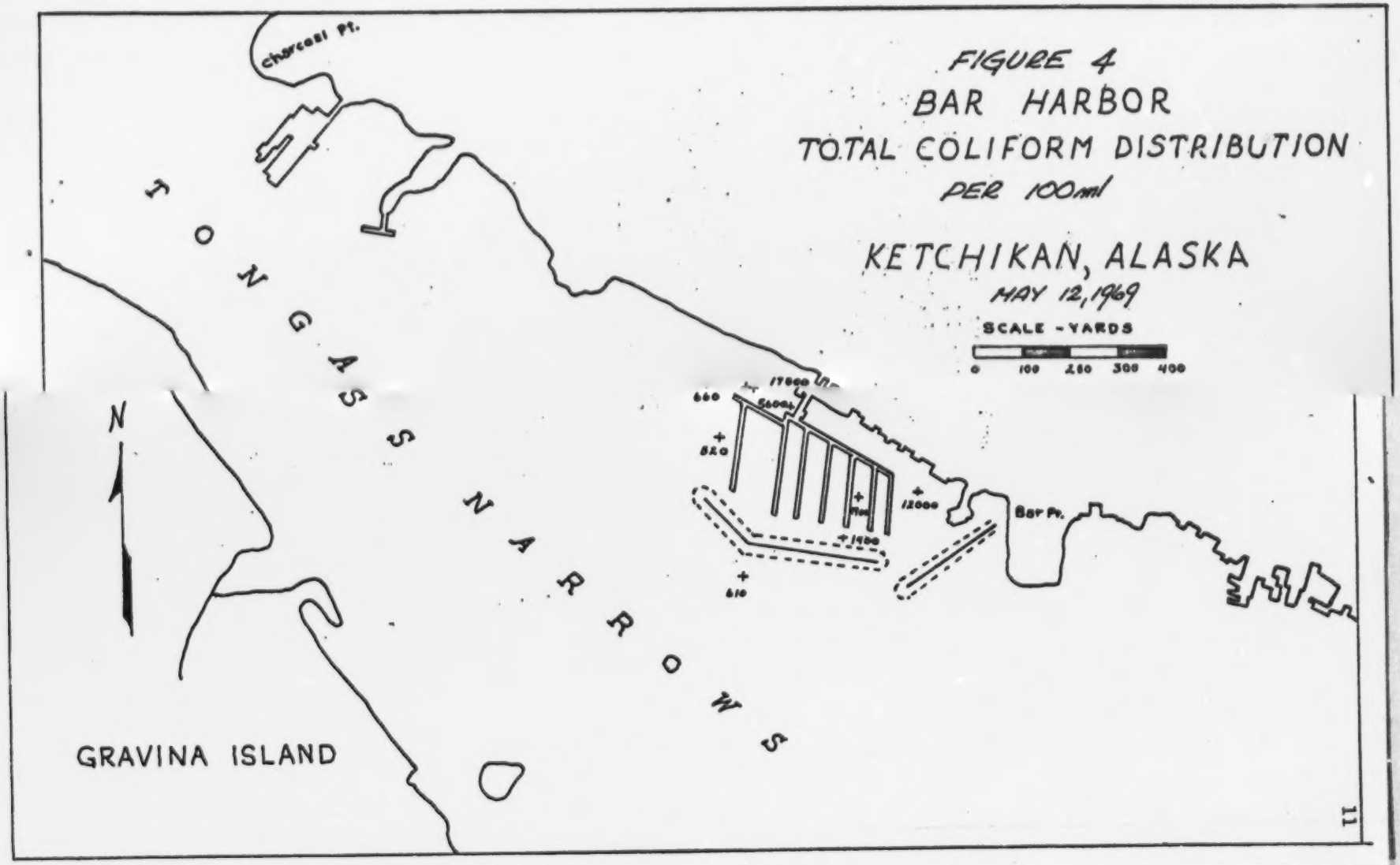

FIGURE 4

BAR HARBOR

TOTAL COLIFORM DISTRIBUTION

PER 100ml

KETCHIKAN, ALASKA

MAY 12, 1969

SCALE - YARDS

0 100 200 300 400

Oceanographic

Currents, salinity, temperature and dissolved oxygen were measured along transects established across Tongass Narrows adjacent to Ketchikan. Measurements were made along both the vertical and horizontal axes of the transects. A current meter and current drogues were employed to establish current speed and direction. Salinity and temperature profiles were conducted with a salinometer.

Dissolved oxygen (D.O.) samples were collected in Nansen Samplers and transferred to standard D.O. bottles. The D.O. samples were fixed immediately using the azide modification of the Winkler method (See "Standard Methods", previously referenced). Fixed D.O. samples were then transported to the laboratory for titration.

RESULTS AND DISCUSSION

All field data collected during the survey are on file and available at the offices of the Federal Water Pollution Control Administration, 501 Pittock Block, Portland, Oregon 97205.

Bacteriological

A summary of the routine bacteriological data is presented in Table 1. These data indicate that total coliform densities were excessively high at many stations, particularly in Bar Harbor and at the Mission, Mill, Dock and Grant Street stations along the city waterfront. The average total coliform density at the surface was 41,000/100ml for the six routine sampling stations located along downtown Ketchikan and in Bar Harbor. The associated fecal coliform average for these stations was 8,600/100ml.

Results of the surface water analyses (Table 1) for total and fecal coliforms show that State bacteriological water quality standards were exceeded in many areas along the Ketchikan waterfront. The applicable State water quality standard stipulates:

"Organisms of the Coliform Group by Most Probable Number (MPN) or equivalent Membrane Filter (MF), using a representative number of samples (where associated with fecal sources) - Average less than 1,000 per 100ml with 20% of samples not to exceed this number; No sample shall exceed 2,400 per 100ml."

Table 2 compares the observed data with the State bacteriological standard.

TABLE 2

COMPARISON OF COLIFORM DATA WITH WATER QUALITY STANDARDS

Coliform Bacteria Water Quality Standard	Number of Stations in Violation
Average exceeds 1000/100ml	11
20% of values exceed 1000/100 ml	13
Any value exceeds 2400/100ml	12

Thirteen of the routine sampling stations were in violation of one or more of the State water quality criteria.

TABLE 1
SUMMARY OF RESULTS FOR SURFACE SAMPLE ANALYSES
TOTAL AND FECAL COLIFORMS

STATION	LOCATION	Number of SAMPLES	TOTAL COLIFORMS/100ML			FECAL COLIFORMS/100ML		
			MAXIMUM	MINIMUM	ARITHMETIC AVERAGE	MAXIMUM	MINIMUM	ARITHMETIC AVERAGE
1	Ferry Terminal	2	1,800	90	950	300	<10	160
2	Hospital	2	180	80	130	40	<10	25
3	North-Bar Harbor	4	100,000	480	37,000	26,000	40	8,700
4	Outside Bar Harbor Breakwater	3	610	<10	220	90	<10	36
5	South Bar Harbor	4	120,000	12,000	62,000	18,000	5,400	11,000
6	South of Bar Point	3	60,000	100	20,000	1,500	<10	510
7	Edwards Wire Rope	3	16,000	50	5,400	6,100	<10	2,000
8	Alaska Outboard	2	190	130	160	50	10	30
9	Nordby Marine Store	2	13,000	240	6,600	1,400	60	730
10	Paul M. Hansen Co.	2	4,000	2,000	3,000	360	190	280
11	Grant St.	3	7,100	3,000	4,700	2,900	430	1,300
12	Dock St.	4	59,000	2,200	28,000	12,000	590	5,800
13	Mission St.	4	250,000	1,400	90,000	46,000	260	20,000
14	Mill St.	3	70,000	140	24,000	11,000	40	3,700
15	Entrance-Thomas Basin	3	2,000	450	980	430	190	280
16	South of Thomas Basin	2	690	70	380	190	<10	100
17	B.C.F. Dock	4	86,000	160	22,000	24,000	30	6,100
18	Ketchikan Creek	2	30	<10	20	<10	<10	<10

The extremely high coliform densities observed in the downtown Ketchikan and Bar Harbor areas were found near municipal sewage outfalls. Close interval samples were collected at these locations for the purpose of determining the extent of area affected. A plot of results obtained from these samples is presented in Fig.'s 3 and 4. It is apparent from these data that much of Bar Harbor is adversely affected by sewage discharges. The affected area adjacent to downtown Ketchikan extends at least 400 feet offshore.

Coliform analyses on Ketchikan Creek (Stn. 18 on Fig. 2) were uniformly low. Samples also were collected north to Ward Cove during a period when the tide was running towards Ketchikan, to observe the bacterial impact, if any, from operations in the pulp mill area. Results indicated that coliform bacteria from Ward Cove were not significant south of Peninsula Point.

Aesthetic Considerations

Fecal solids and clouds of shredded toilet paper were observed on the shoreline and floating at many points along the Ketchikan waterfront. These solids are aesthetically offensive as well as potentially dangerous sources of pathogenic organisms. Bacteria contained in the fecal solids are protected from the antibacterial effect of seawater thereby greatly extending their viability.

In those areas with poor circulation, such as Bar Harbor, the toilet paper settles out rapidly forming unsightly toilet paper collages around the outfalls at low tide. Sludge deposits have also accumulated in these areas. The decomposition of this sludge produces gas evolutions which have an offensive odor.

Factors Affecting Sewage Dispersion

Domestic sewage discharged from submerged marine outfalls will rise toward the surface because it is lighter in density than the saline receiving water. The sewage will be diluted as it rises towards the surface by mixing with the surrounding seawater.

The amount of dilution depends mainly on the depth and size of the outfall, and the difference in density between the sewage and the seawater. Generally dilution is increased by increasing the depth of the outfall, and reducing the diameter of the outfall (ports). Under certain conditions of density stratification it may be possible to locate and design an outfall diffuser system which prevents the diluted sewage from reaching the surface.

As expected, sewage from Ketchikan's shallow submerged outfalls reached the water surface during the study, and was observed both in terms of a surface boil over the outfalls and by concentration of coliform bacteria at the surface. This latter feature is illustrated in Table 3, which compares surface and depth bacterial densities.

TABLE 3

COMPARISON OF COLIFORM DENSITIES
IN PAIRED
SURFACE AND DEPTH SAMPLES

STATION	DEPTH (Ft.)	TOTAL COLIFORMS 100ml
5	0.5	47,000
	7.0	260
10	0.5	4,000
	33.0	20
11	0.5	3,900
	31.0	50
12	0.5	38,000
	29.0	110

Significantly, most human contact with the receiving water occurs at the surface where the bacteria associated with the sewage are most concentrated.

The lateral and longitudinal movement of sewage laden water depends upon oceanic, tidal, and wind driven currents. Tidal

current predictions for Tongass Narrows, from U.S. Coast and Geodetic Survey (USC & GS) "Tidal Current Tables, 1969, Pacific Coast of North America and Asia," indicate that during this study, flood tide currents in a northwest direction would have a velocity of approximately 0.6 knot. Ebb tide currents in a southeast direction at approximately 0.3 knot were also predicted. Field studies by the USC & GS have indicated that 0.25 to 0.50 knot currents flow northward through Tongass Narrows. This non-tidal current augments the flood tide current and opposes the ebb tide current, often resulting in several hours of very weak or no net current movement in Tongass Narrows. Field current data collected during the May 7-12 study was in reasonable agreement with the predicted values. Maximum mid-channel surface currents of 0.50 to 1.0 knots were responsive primarily to tidal forces, but were also affected by the wind. Currents near shore were generally in the same direction as mid-channel currents, but were significantly slower. However, shoreline surface currents responding to wind stresses were at times contrary to the direction of the tidal current. Local weather records indicate that local winds are predominantly from the southwest. The combined effect of the permanent non-tidal northerly current, prevailing southwest winds and strong flood tide is a net northward water excursion with an unpredictable shoreward component of wind driven surface currents.

In summary, it is the combination of these factors - - - (1) Stratification of discharged sewage near the surface because of its lighter relative density (2) slow nearshore tidal currents with net northward movement in Tongass Narrows; and (3) an onshore wind component - - which tend to confine Ketchikan's sewage discharges in the surface waters of the waterfront area, and to move it slowly northward past the city.

Discussion of Recommendations

Present sewage disposal practices at Ketchikan do not take advantage of the dilution potential of Tongass Narrows. Available depths of more than 100 feet, and the generally observed density profile (salinity-temperature) for southeast Alaskan coastal waters, indicate that a properly designed and located diffuser outfall would provide at least a one-hundred-fold dilution of sewage before it reaches the surface. The average total coliform concentration of raw sewage usually ranges between 10,000,000 and 30,000,000 per 100 ml, however, and a deep water outfall alone would not provide initial sewage dilution adequate to meet the Water Quality Standard of 1000 per 100 ml. A sewage system providing for collection, primary treatment and adequate effluent chlorination could be expected to reduce coliform concentrations to a level where outfall dilution would produce an acceptable bacterial quality in the receiving waters. The outfall for such a system should be located near mid-channel in Tongass Narrows, to remove the sewage from the city waterfront, and to take advantage of the greater depth (dilution potential) and stronger currents. It should also be placed toward the northern edge of the city, where the predominantly northward current would minimize circulation of sewage discharges past the waterfront area.

APPENDIX

20-a

BOARD MEMBERS
C. PRESTON LOCHER, CHAIRMAN
CARL H. PORTER, 1ST VICE CHAIRMAN
JAMES W. DALTON, 2ND VICE CHAIRMAN
GEORGE SHARROCK, COMMISSIONER OF COMMERCE
IRA Z. WALKER, MEMBER

20-b

Alaska STATE HOUSING AUTHORITY

JAY C. MUELLER
EXECUTIVE DIRECTOR

RECEIVED
SEP 23 1968
ALASKA WATER LABORATORY

September 23, 1968

Director
Alaska Water Laboratory
Federal Water Pollution Control
Administration
University of Alaska
College, Alaska 99701

Re: Ketchikan Gateway Borough
Water Survey

Dear Sir:

By Resolution No. 61 of September 3, 1968, the Ketchikan Gateway Borough has requested the Alaska State Housing Authority to assist the Borough in obtaining a survey of the waters of Tongass Narrows by your laboratory.

The Ketchikan Gateway Borough, its Assembly and Administrator, are aware of the problems in the Ketchikan area and are taking the actions necessary to insure a safe and attractive community. They have made use of many of the programs available to them having already completed a Comprehensive Development Plan. At the present time they are working on over-all planning for water distribution and sewage collection systems, and should be commended for their concern about water quality in their area.

If it is within the scope of the work you are proposing to do in the next fiscal year, we would urge that you comply with the request of the Borough and survey the waters of the Tongass Narrows.

If we can be of further assistance in this matter, please do not hesitate to call.

Very truly yours,

ALASKA STATE HOUSING AUTHORITY

Jay C. Mueller
Executive Director

MP:hd
cc: Ketchikan Gateway Borough

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STATE OF ALASKA
OFFICE OF THE GOVERNOR
JUNEAU

September 26, 1968

Mr. E. K. Day
Water Laboratory
College, Alaska 99701

Dear Mr. Day:

Mr. George Anderson, City Councilman from Ketchikan, was a recent visitor to the Governor's Office. Mr. Anderson was concerned about the Water Quality Standards Act which has to be implemented by 1972. He feels that the City of Ketchikan, and rightfully so, should start now on their planning to have the requirements completed by 1972.

As you know, there are no facilities in the Ketchikan area to make the different water tests or check the other requirements. Mr. Anderson inquired as to the availability of your laboratory services in helping Ketchikan make the required tests. I know you do the tests for Ketchikan Pulp and Sitka Pulp and would appreciate it if you could coordinate testing in the channel in front of Ketchikan with your trips to that area.

It would be appreciated if you would write Mr. George Anderson, 1066 Fair Street, Ketchikan 99901, and let him know what assistance you might be able to give him.

Sincerely yours,

W. L. Kubley
Legislative Assistant

SEP 30 1968

STATION NUMBER	LOCATION
1	South Side of Ferry Dock
2	Near Shoreline - Mouth of Hoadly Creek
3	Near Outfall - North Side of Bar Harbor
4	Outside Bar Harbor Breakwater
5	Near Outfall - South Side of Bar Harbor
6	Near Shoreline - South of Bar Point
7	Pierhead Line at Edwards Wire Rope
8	Pierhead Line - Alaska Outboard
9	Pierhead Line - Nordeby Marine Store
10	Pierhead Line - Paum M. Hansen Co.
11	Pierhead Line - Grant St.
12	Pierhead Line - Dock St.
13	Pierhead Line - Mission St.
14	Pierhead Line - Mill St.
15	Entrance to Thomas Basin
16	Near Shoreline just South of Thomas Basin
17	End of Bureau of Commercial Fisheries Dock
18	Ketchikan Creek at Park Ave. Bridge